DPP- (2) Mossbauer Spectroscopy

1. To record mösspauer spectrum of Fe containing sample, a source X is used. X after the nuclear transformation gives r-radiation used in M.B spectroscopy.

   (a) ^{57}Fe, β-emission (b) ^{57}Co, β-emission (c) ^{57}Co, e^{Θ}-capture (d) ^{57}Fe, e^{Θ}-capture

2. To record mössbauer spectra of Sn containing sample, a source X is used. X after the nuclear transformation gives r-radiation used in M.B spectroscopy.

   (a) ^{57}Fe, β-emission (b) ^{57}Co, β-emission (c) ^{119}Sn (d) ^{57}Fe, e^{Θ}-capture

3. Which radiations used in Mössbauer spectroscopy?

   (a) X-ray (b) r-rays (c) Radiowaves (d) Microwaves

4. For a Nuclei to be Mössbauer active:

   (a) Nuclear magnetic quantum number equal to zero

   (b) Nuclear magnetic quantum number less than zero

   (c) Nuclear magnetic quantum number greater the zero

   (d) None of these

5. What will be the Excited state I value for ^{57}Fe Nuclei

   (a) $\frac{1}{2}$ (b) $\frac{3}{2}$ (c) $\frac{5}{2}$ (d) 1

6. What will be the Ground state I value for ^{57}Fe Nuclei

   (a) $\frac{1}{2}$ (b) $\frac{3}{2}$ (c) $\frac{5}{2}$ (d) $\frac{7}{2}$

7. What will be the Ground state I value for ^{119}Sn Nuclei

   (a) $\frac{1}{2}$ (b) $\frac{3}{2}$ (c) $\frac{5}{2}$ (d) 1

8. What will be the Excited state I value for ^{119}Sn Nuclei

   (a) $\frac{1}{2}$ (b) $\frac{3}{2}$ (c) $\frac{5}{2}$ (d) 1

9. Which of the following Nuclei is Mössbauer active Nuclei?

   (a) ^{1}H (b) ^{13}C (c) ^{57}Fe (d) ^{119}Sn

10. Which of the following Nuclei is Mössbauer active Nuclei?

    (a) ^{57}Fe (b) ^{57}Co (c) ^{119}Sn (d) ^{127}I

11. Among the following those can act as Mössbauer nuclei

    (a) ^{129}I (b) ^{57}Co (c) ^{57}Fe (d) ^{121}Sb

12. Calculate the recoil velocity and energy of the free Mössbauer nucleu ^{119}Sn when emitting a r-ray of frequency 5.76×10^{18} Hz. What is the Doppler shift of the r-ray frequency to an outside observen?

..... $\times 10^{10}$ Hz

13. Caluculate the Doppler velocity corresponding to the natural line width of the r-ray emission from 14.4 keV excitd state of ^{57}Fe nucleus having a half-lif of 9.8×10^{-8}s.

..... ($m\ ms^{-1}$)

14. A mȍssbauer nucleus ^{57}Fe makes the transition from the Excited state of energy 14.4 keV to the ground state. What is he recoil energy?

(a) 1.95×10^{-3} eV (b) 3.11×10^{-22} J (c) 57×10^{-3} J (d) 9.4×10^{-26} eV

15. Calculate the recoil velocity of a free Mössbauer nucleus of mass 1.67×10^{-25} kg (equivalent at wt. 100) when emitting a r-ray of wavelength 0.1 nm. What is he Doppler shift of r-ray frequency to an outside observer?

(a) 39.6×10^{10} Hz (b) 42×10^{10} Hz (c) 8×10^{9} Hz (d) 55×10^{12} Hz

16. In $^{57}Fe^{*}$ Mössbauer experiment, source of 14.4 keV (equivalent to 3.48×10^{12} MHz) is move towards absorbr at a velocity of 2.2 mms^{-1}. The shift of frequency of the source for this sample is :

(a) 35.5 MHz (b) 25.5 MHz (c) 20.2 MHz (d) 15.5 MHz

17. The recoil energy of a Mȍssbauyer nuclide of mass 139 amu is 2.5 MeV. The energy emitted by the nucleus in keV is:

(a) 12.5 (b) 15.0 (c) 20.5 (d) 25.0

18. Find out the number of Mȍssbauyer signal in Fe_2O_3?

(a) One (b) Two (c) Three (d) Four

19. Find out the number of Mȍssbauer signal in $Fe_3(Co)_{12}$.

(a) One (b) Two (c) Three (d) Four

20. Which of the following statements are true for Mössbauer sectrophotometer:

(a) Sample will be always solid.

(b) The excited stat of emitter must hav a precursor which is long-lived an rasonably easy to handle.

(c) The energy of nuclear transistion must be large enough to give useful radiation means that E_r must lie between 10 and 150 keV.

(d) All of these

ANSWER KEY

1.	(c)	2.	(c)	3.	(b)	4.	(c)	5.	(b)	6.	(a)	7.	(a)
8.	(b)	9.	(c,d)	10.	(a,c,d)	11.	(a,c,d)	12.	(123.57)			13.	(0.097)
14.	(a,b)	15.	(a)	16.	(b)	17.	(d)	18.	(a)	19.	(b)	20.	(d)

HINTS & SOLUTION

12. **Soln.** Mass of $^{119}Sn = \dfrac{119\times10^{-3}\ kg\ mol^{-1}}{6.023\times10^{23}\ mol^{-1}} = 19.76 \times 10^{-26}\ kg$

Recoil momentum of the nucleus $= \dfrac{h\nu}{c}$

Recoil velocity of the nucleus, $\nu = \dfrac{h\nu / c}{\text{mass of the nucleus}}$

$$\nu = \frac{(6.626\times10^{-34}\ Js)(5.76\times10^{18}\ s^{-1})}{(3\times10^{8}\ m/s)(19.76\times10^{-26}\ kg)}$$

$$= 64.36\ ms^{-1}$$

Recoil energy $E_{re} = \dfrac{1}{2}mv^2 = \dfrac{1}{2}(19.767\times10^{-26}\ kg)(64.36\ m/s)^2$

$$= 40.94 \times 10^{-23}\ J = 2.56 \times 10^{-3}\ eV$$

Doppler shift $\Delta\nu = \nu\dfrac{v}{c} = \dfrac{(5.76\times10^{18}\ s^{-1})64.36\ m/s}{3\times10^{8}\ m/s}$

$$= 123.57\ Hz$$

13. **Sol.** Mean lifetime, $\Delta t = \dfrac{\text{Half Life}}{\ln 2} = \dfrac{9.8\times10^{-8}\ s}{\ln 2} = 14.138 \times 10^{-8}\ s$

Uncertainty in freq, $\Delta\nu = \dfrac{1}{2\pi\Delta t} = \dfrac{1}{2\pi\times(14.139\times10^{-8}\ s)} = 1.125 \times 10^{6}\ Hz$

Energy of the emitted, r-ray $E_r = 14.4\ keV = 23.04 \times 10^{-16}\ J$

Frequency of r-ray, $\nu = \dfrac{(1.125\times10^{6}\ s^{-1})(3\times10^{8}\ m/s)}{3.477\times10^{18}\ s^{-1}}$

$$= 0.97 \times 10^{-4}\ ms^{-1}$$

$$= 0.097\ mms^{-1}$$

14. **Sol.** Recoil velocity $E_{re} = \dfrac{E_0^2}{2mc^2}$

Energy of gamma-ray, $E_0 = (14.4 \times 10^{2}\ eV)\ (1.6 \times 10^{-19}\ J/eV)$

$$= 23.04 \times 10^{-16}\ J$$

Mass of the nucleus, $m = \dfrac{57\times10^{-3}\ kg\ mol^{-1}}{6.02\times10^{23}\ mol^{-1}} = 9.468 \times 10^{-26}\ kg$

15.**Sol**. Recoil velocity, $\nu = \dfrac{\text{recoil momentum of nucleus}}{\text{mass of nucleus}}$

$= \dfrac{h/J}{m}$

$\nu = \dfrac{6.626\times10^{-34}\,J/s}{(0.1\times10^{-9}\,m)(1.67\times10^{-25}\,kg)} = 39.68\ ms^{-1}$

Doppler shift, $\Delta\nu = \nu\dfrac{V}{c} = \dfrac{V}{\lambda} = \dfrac{39.68}{0.1\times10^{-9}\,m}$

$= 39.68 \times 10^{10}$ Hz

$E_{re} = \dfrac{(23.04\times10^{-16}\,J)^2}{2(9.468\times10^{-26}\,kg)(3\times10^{8}\,m/s)^2} = \boxed{3.1148\times10^{-22}\,J}$

$= \boxed{1.95\times10^{-3}\,eV}$

16.**Soln**. Frequency shift $(\Delta\nu) = \dfrac{V\nu}{c}$; where V = relative velocity of source and observer

$\nu =$ frequency of emittd radiaion

$\therefore\ \Delta\nu = \dfrac{2.2\times10^{-3}\,ms^{-1}\times3.48\times10^{18}\,(Hz)}{3\times10^{8}\,ms^{-1}}$

$= 2.55 \times 10^{7}$ Hz

$= \boxed{25.5\,MHz}$

17.**Soln.** Recoil energy $R = \dfrac{\epsilon_r^2}{2mc^2}$

Recoil enery $R = \dfrac{536\,E_r^2}{M}\,eV$

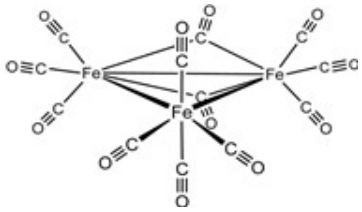
$2.5 \times 10^{6} = \dfrac{536\,E_r^2}{139\times931.5}$

$E_r = \sqrt{\dfrac{2.5\times139\times931.5\times10^{6}}{536}}$

$\boxed{E_r = 24.57\times10^{3}\,eV}$

18.**Soln.** Both Fe are equivalent 1 signal

19.**Soln**. $Fe_3(Co)_{12}$



2 Fe are equivalent and 1 Fe are different 2 signals for Fe.